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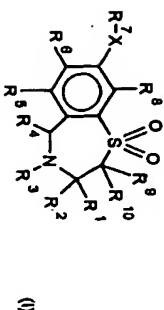
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(54) Hypolipidemic 1,4-benzothiazepine-1,-dioxides

(57) The present invention is concerned with new hypolipidemic compounds, with processes and novel intermediates for their preparation, with pharmaceutical compositions containing them and with their use in medicine, particularly in the prophylaxis and treatment of hyperlipidemic conditions, such as atherosclerosis.

Compounds of the formula (I):



wherein R¹ to R¹⁰ and X are as defined.

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Description

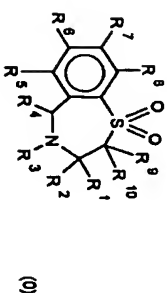
The present invention is concerned with new hypolipidemic compounds, with processes and novel intermediates for their preparation, with pharmaceutical compositions containing them and with their use in medicine, particularly in the prophylaxis and treatment of hyperlipidemic conditions, such as atherosclerosis.

Hyperlipidemic conditions are often associated with elevated plasma concentrations of low density lipoprotein (LDL) cholesterol and very low density lipoprotein (VLDL) cholesterol. Such concentrations can be reduced by decreasing the absorption of bile acids from the intestine. One method by which this may be achieved is to inhibit the bile acid active uptake system in the terminal ileum. Such inhibition stimulates the conversion of cholesterol to bile acid by the liver and the resulting increase in demand for cholesterol produces a corresponding increase in the rate of clearance of LDL and VLDL cholesterol from the blood plasma or serum.

There has now been identified a novel class of heterocyclic compounds which reduce the plasma or serum concentrations of LDL and VLDL cholesterol and in consequence are particularly useful as hypolipidemic agents. By decreasing the concentrations of cholesterol and cholesterol ester in the plasma, the compounds of the present invention retard the build-up of atherosclerotic lesions and reduce the incidence of coronary heart disease-related events. The latter are defined as cardiac events associated with increased concentrations of cholesterol and cholesterol ester in the plasma or serum.

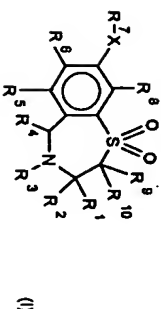
For the purposes of this specification, a hyperlipidemic condition is defined as any condition wherein the total cholesterol concentration (LDL + VLDL) in the plasma or serum is greater than 240 mg/dl. (6.21 mmol/L) (J. Amer. Med. Assn., 256, 20, 2949-2959 (1986)).

International Patent Application No. WO 86/05188 describes compounds of formula (I):



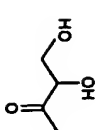
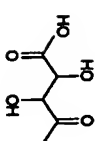
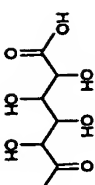
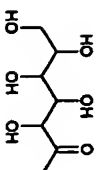
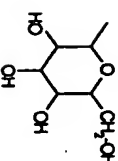
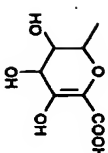
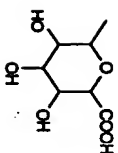
We have now discovered a group of compounds which have greater hypolipidemic activity in vivo than those specifically disclosed in International Patent Application No. WO 86/05188. The compounds differ in the definition of group R⁷.

Accordingly, the present invention provides compounds of the formula (I):



wherein

R¹ is a straight chained C₁₋₄ alkyl group;
R² is a straight chained C₁₋₄ alkyl group;
R³ is hydrogen or a group OR¹¹ in which R¹¹ is hydrogen, optionally substituted C₁₋₄ alkyl or a C₁₋₄ alkyloxy group;



Sulfonyl X is -O-.

Sulfonyl R⁹ and R¹⁰ are hydrogen, methyl or ethyl, hydrogen. Preferably R⁹ and R¹⁰ are both hydrogen.

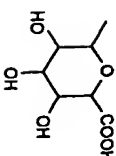
Sulfonyl R⁴ is propyl or phenyl optionally substituted, preferably at the 4- and/or 3-position by halogen, methyl,

ethyl, methoxy, ethoxy, trifluoromethyl, hydroxy, carboxy or $\text{Cl}(\text{CH}_2)_2\text{SO}_2\text{H}$. Preferably R⁴ is unsubstituted phenyl.

In the compounds of the formula (III), sulfonyl at least one and preferably all of R⁹, R⁹ and R¹⁰ are hydrogen. When R⁹, R⁹ and R¹⁰ are other than hydrogen then they are sulfonyl C₁₋₄ alkyl optionally substituted by fluoro, C₁₋₄ alkoxy, halogen or hydroxy, most suitably methyl, methoxy, hydroxy, trifluoromethyl or chloro and preferably methoxy.

In the compounds of the formula (IV), sulfonyl two or three of R⁹, R⁹ and R¹⁰ are hydrogen, the others being C₁₋₄ alkyl optionally substituted by fluoro, C₁₋₄ alkoxy, halogen or hydroxy and most suitably methyl, methoxy, hydroxy, trifluoromethyl or chloro and preferably methoxy.

In the compounds of formula (Va), sulfonyl at least one and preferably all of R⁹, R⁹ and R¹⁰ are hydrogen. When R⁹, R⁹ and R¹⁰ are other than hydrogen then they are sulfonyl C₁₋₄ alkyl optionally substituted by fluoro, C₁₋₄ alkoxy, halogen or hydroxy, most suitably methyl, methoxy, hydroxy, trifluoromethyl or chloro and preferably methoxy. Most preferably, R⁴ is n-butyl, R⁹ is ethyl, R⁹, R⁹, R⁹ and R¹⁰ are hydrogen, R⁴ is phenyl and R⁷ is



Pharmaceutically acceptable salts are particularly suitable for medical applications because of their greater aqueous solubility relative to the parent, i.e. basic, compounds. Such salts must clearly have a pharmaceutically acceptable anion or cation. Suitable pharmaceutically acceptable acid addition salts of the compounds of the present invention include those derived from inorganic acids, such as hydrochloric, hydrobromic, phosphoric, metaphosphoric, nitric, sulfuric and sulphuric acids, and organic acids, such as acetic, benzenesulphonic, benzoic, citric, ethanesulphonic, fumaric, gluconic, glycolic, isobutyric, lactic, lactobionic, maleic, malic, methanesulphonic, succinic, p-toluenesulphonic, tartaric and trifluoroacetic acids. The chloride salt is particularly preferred for medical purposes. Suitable pharmaceutically acceptable base salts include ammonium salts, alkali metal salts, such as sodium and potassium salts, and alkaline earth salts, such as magnesium and calcium salts.

Salts having a non-pharmaceutically acceptable anion are within the scope of the invention as useful intermediates for the preparation or purification of pharmaceutically acceptable salts and/or for use in non-therapeutic, for example, in vitro, applications.

The term "physiologically functional derivative" as used herein refers to any physiologically acceptable derivative of a compound of the present invention, for example, an ester, which upon administration to a mammal, such as a human, is capable of providing (directly or indirectly) such a compound or an active metabolite thereof.

A further aspect of the present invention is products of the compounds of the invention. Such products can be metabolised in vivo to give a compound according to the invention. These products may or may not be active in their own right.

The compounds of the present invention can also exist in different polymorphic forms, for example, amorphous and crystalline polymorphic forms. All polymorphic forms of the compounds of the present invention are within the scope of the invention and are a further aspect thereof.

The term "alkoxy" as used herein refers, unless otherwise stated, to a monovalent straight or branched chain radical, Likewise, the term "alkoxy" refers to a monovalent straight or branched chain radical attached to the parent molecular moiety through an oxygen atom. The term "phenylalkoxy" refers to a monovalent phenyl group attached to a divalent C₁₋₄ alkylene group which is itself attached to the parent molecular moiety through an oxygen atom.

The compounds of formula (I) exist in forms wherein the carbon centres -C(R¹)(R²)- and -CH(R⁴)-, is a chiral. The present invention includes within its scope each possible optical isomer substantially free, i.e. as associated with less than 5%, of any other optical isomer(s), and mixtures of one or more optical isomers in any proportions, including racemic mixtures.

For the purposes of this specification, the absolute configurations of the stereocentred carbon centres are given in the order -C(R¹)(R²), then -CH(R⁴).

In those cases where the absolute stereochemistry at -C(R¹)(R²)- and -CH(R⁴)- has not been determined, the compounds of the invention are defined in terms of the relative positions of the R¹/R² and H/R⁴ substituents. Thus these compounds wherein the bulkier of the R¹ and R² substituents, i.e. the substituent of higher mass, and the R⁴ substituent are both located on the same side of the thiazepine ring are referred to herein as "cis", and those compounds in which the bulkier of the R¹ and R² substituents are located on opposite sides of the ring are referred to as "trans" and are preferred. It will be evident to a skilled person that both "cis" and "trans" compounds of the invention can each exist in two

enantiomeric forms which are individually designated "(+)" or "(-)" according to the direction of rotation of a plane of polarised light when passed through a sample of the compound. Cis or trans compounds of the invention in which the individual enantiomers have not been resolved are referred to herein using the prefix "(+)".

According to further aspects of the invention, there are also provided:

- (a) compounds of formula (I) and pharmaceutically acceptable salts, solvates and physiologically functional derivatives thereof for use as therapeutic agents, particularly in the prophylaxis and treatment of clinical conditions for which a bile acid uptake inhibitor is indicated, for example, a hyperlipidemic condition, such as atherosclerosis;
- (b) pharmaceutical compositions comprising a compound of formula (I) or one of its pharmaceutically acceptable salts, solvates, or physiologically functional derivatives, at least one pharmaceutically acceptable carrier and, optionally, one or more other physiologically active agents;
- (c) the use of a compound of formula (I) or of a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof in the manufacture of a medicament for the prophylaxis or treatment of a clinical condition for which a bile acid uptake inhibitor is indicated, for example, a hyperlipidemic condition, such as atherosclerosis;
- (d) a method of inhibiting the absorption of bile acids from the intestine of a mammal, such as a human, which comprises administering an effective bile acid absorption inhibiting amount of a compound of formula (I) or of a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof to the mammal;
- (e) a method of reducing the blood plasma or serum concentrations of LDL and VLDL cholesterol in a mammal, such as a human, which comprises administering an effective cholesterol reducing amount of a compound of formula (I) or of a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof to the mammal;
- (f) a method of reducing the concentrations of cholesterol and cholesterol ester in the blood plasma or serum of a mammal such as a human, which comprises administering an effective cholesterol and cholesterol ester reducing amount of a compound of formula (I) or of a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof to the mammal;
- (g) a method of increasing the fecal excretion of bile acids in a mammal, such as a human, which comprises administering an effective bile acid fecal excretion increasing amount of a compound of formula (I) or of a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof to the mammal;
- (h) a method for the prophylaxis or treatment of a clinical condition in a mammal, such as a human, for which a bile acid uptake inhibitor is indicated, for example, a hyperlipidemic condition, such as atherosclerosis, which comprises administering a therapeutically effective amount of a compound of formula (I) or of a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof to the mammal;
- (i) a method of reducing the incidence of coronary heart disease-related events in a mammal, such as a human, which comprises administering an effective coronary heart disease-related events reducing amount of a compound of formula (I) or of a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof;
- (j) a method of reducing the concentration of cholesterol in the blood plasma or serum of a mammal, such as a human, which comprises administering an effective cholesterol reducing amount of a compound of formula (I);
- (k) processes for the preparation of compounds of formula (I) (including salts, solvates and physiologically functional derivatives thereof as defined herein); and
- (l) novel chemical intermediates in the preparation of compounds of formula (I).
- (m) the compounds of Synthetic Example 1 to 5 as hereinafter disclosed.

Hereinafter all references to "compound(s) of formula (I)" refer to compound(s) of formula (I) as described above together with their salts, solvates and physiologically functional derivatives as defined herein.

The amount of a compound of formula (I) which is required to achieve the desired biological effect will, of course, depend on a number of factors, for example, the specific compound chosen, the use for which it is intended, the mode

of administration and the clinical condition of the recipient. In general, a daily dose is in the range of from 0.3 mg to 100 mg (typically from 3 mg to 50 mg) per day per kilogram bodyweight, for example, 3-10 mg/kg/day. An intravenous dose can, for example, be in the range of from 0.3 mg to 1.0 mg/kg, which can conveniently be administered as an infusion of from 10 to 100 mg per kilogram per minute. Infusion fluids suitable for this purpose can contain, for example, from 0.1 mg to 10 mg, typically from 1 mg to 10 mg, per millilitre. Unit doses can contain, for example, from 1 mg to 10 g of the active compound. Thus ampoules for injection can contain, for example, from 1 mg to 100 mg and orally administrable unit dose formulations, such as tablets or capsules, may contain, for example, from 1.0 to 1000 mg, typically from 10 to 600 mg. In the case of pharmaceutically acceptable salts, the weights indicated above refer to the weight of the benzothiazepine ion derived from the salt.

For the prophylaxis or treatment of the conditions referred to above, the compounds of formula (I) can be used as the compound per se, but are preferably presented with an acceptable carrier in the form of a pharmaceutical composition. The carrier must, of course, be acceptable in the sense of being compatible with the other ingredients of the composition and must not be deleterious to the recipient. The carrier can be a solid or a liquid, or both, and is preferably formulated with the compound as a unit-dose composition, for example, a tablet, which can contain from 0.05% to 95% by weight of the active compound. Other pharmacologically active substances can also be present including other compounds of formula (I). The pharmaceutical compositions of the invention can be prepared by any of the well known techniques of pharmacy consisting essentially of admixing the components.

Pharmaceutical compositions according to the present invention include those suitable for oral, rectal, topical, buccal (e.g. sub-lingual) and parenteral (e.g. subcutaneous, intramuscular, intradermal, or intravenous) administration, although the most suitable route in any given case will depend on the nature and severity of the condition being treated and on the nature of the particular compound of formula (I) which is being used. Enteric-coated and enteric-coated controlled release formulations are also within the scope of the invention. Preferred are acid and gastric juice resistant formulations. Suitable enteric coatings include cellulose acetate phthalate, polyvinylacetate phthalate, hydroxypropylmethylcellulose phthalate and anionic polymers of methacrylic acid and methacrylic acid methyl ester.

Pharmaceutical compositions suitable for oral administration can be presented in discrete units, such as capsules, cachets, lozenges, or tablets, each containing a predetermined amount of a compound of formula (I); as a powder or granules; as a solution or a suspension in an aqueous or non-aqueous liquid; or as an oil-in-water or water-in-oil emulsion. As indicated, such compositions can be prepared by any suitable method of pharmacy which includes the step of bringing into association the active compound and the carrier (which can constitute one or more accessory ingredients). In general, the compositions are prepared by uniformly and intimately admixing the active compound with a liquid or finely divided solid carrier, or both, and then, if necessary, shaping the product. For example, a tablet can be prepared by compressing or moulding a powder or granules of the compound, optionally with one or more accessory ingredients. Compressed tablets can be prepared by compressing, in a suitable machine, the compound in a free-flowing form, such as a powder or granules optionally mixed with a binder, lubricant, inert diluent and/or surface active dispersing agent(s). Moulded tablets can be made by moulding, in a suitable machine, the powdered compound moistened with an inert liquid diluent.

Pharmaceutical compositions suitable for buccal (sub-lingual) administration include lozenges comprising a compound of formula (I) in a flavored base, usually sucrose and, acacia or tragacanth, and pastilles comprising the compound in an inert base such as gelatin and glycerin or sucrose and acacia.

Pharmaceutical compositions suitable for parenteral administration conveniently comprise sterile aqueous preparations of a compound of formula (I), preferably isotonic with the blood of the intended recipient. These preparations are preferably administered intravenously, although administration can also be effected by means of subcutaneous, intramuscular, or intradermal injection. Such preparations can conveniently be prepared by admixing the compound with water and rendering the resulting solution sterile and isotonic with the blood. Injectable compositions according to the invention will generally contain from 0.1 to 5% w/v of the active compound.

Pharmaceutical compositions suitable for rectal administration are preferably presented as unit-dose suppositories. These can be prepared by admixing a compound of formula (I) with one or more conventional solid carriers, for example, cocoa butter, and then shaping the resulting mixture.

Pharmaceutical compositions suitable for topical application to the skin preferably take the form of an ointment, cream, lotion, paste, gel spray, aerosol, or oil. Carriers which can be used include vaseline, lanoline, polyethylene glycols, alcohols, and combinations of two or more thereof. The active compound is generally present at a concentration of from 0.1 to 15% w/v of the composition, for example, from 0.5 to 2%.

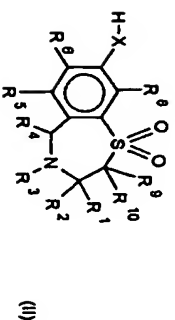
Transdermal administration is also possible. Pharmaceutical compositions suitable for transdermal administration can be presented as discrete patches adapted to remain in intimate contact with the epidermis of the recipient for a prolonged period of time. Such patches suitably contain the active compound in an optionally buffered, aqueous solution, dissolved and/or dispersed in an adhesive, or dispersed in a polymer. A suitable concentration of the active compound is about 1% to 35%, preferably about 5% to 15%. As one particular possibility, the active compound can be delivered from the patch by electrotransport or iontophoresis, for example, as described in Pharmaceutical Research, 2(6), 318

(1986).

The compounds of the invention can be prepared by conventional methods known to a skilled person or in an analogous manner to processes described in the art.

For example, compounds of the formula (I) can be prepared by a process which comprises

e) acylation of a compound of formula (II)



by standard procedures (e.g. with *N,N*-carbonyldiimidazole) at the -X-H group

- a) substitution of a compound of formula (II) by standard procedures at the X-H group or a) glycosylation or glucuronidation a compound of formula (II) at the X-H group, especially using the imidazole method and
- b) cleavage of protecting groups, especially of hydroxyl and amino functional groups, e.g. acetyl by hydrolysis, benzyl by hydrogenolysis.

The compounds of formula (I) can be prepared according to the method of preparation disclosed in WO 96/05138. The compounds of formula (I) substantially free of other optical isomers can be obtained either by chiral synthesis, for example, by the use of the appropriate chiral starting material, such as the enidine, or by resolution of the products obtained from achiral syntheses, for example, by chiral HPLC or by classical resolution with chiral acids.

²⁵ Optional conversion of a compound of formula (I) comprising a basic substituent, to a corresponding acid addition salt may be effected by reaction with a solution of the appropriate acid, for example, acetic acid, to form a corresponding acid addition salt which may be isolated by crystallization or precipitation from the reaction mixture.

In addition, compounds of the formula (I) may be converted to different compounds of the formula (I) by standard methods known or ascertainable from the literature to those skilled in the art, for example by alkylation of a hydroxy group.

In order to prove the greater hydrophilic activity of the compounds according to the invention tests were carried out by means of three genetically modified cell lines. These were derivatives of the generally known 'Chinese hamster ovary' (CHO) cell line, which on account of incorporated expression plasmids additionally produced sodium-dependent bile acid transporters. The first cell line (CHO-pBilAT8) was in this case the result of the fusion (BilAT8), the second (CHO-pHilAT8) the final transporter of the human (HilAT8) and the third (CHO-pHilBilAT8) the hepatic trans-
porter of the human. All plasmids were based on the standard plasmid pCDNA1neo, which as important elements has a cytomegaloviral promoter for the permanent expression of heterologous genes and a gene for the production of cellular resistance against the substance G418.

60 The starting material for the production of the plasmid for the RIBAT-producing cell line (pRIBAT5) was total RNA of the terminal ileum of the rabbit. From this by means of an RT-PCR procedure (reverse transcriptase reaction, followed by a polymerase chain reaction) with the aid of the oligonucleotides

5'-actataaataatgaagagcttcttctt-3', a cDNA was synthesized which contained the total protein-coding region of the R18AT and also 41 base pairs on the 5'-adjacent and 31 base pairs on the 3'-adjacent untranslated region. This region on the 5'-end and Xba I (at the 3'-end). The obtained cDNA and DNA of plasmid pCDNAneo were digested using the two restriction enzymes mentioned and resulting fragments were combined by means of ligase to give the expression plasmid pR18AT8.

The plasmid for the HIBAT-producing cell line (pHIBAT8) was prepared analogously to pRIBAT8. In this case, total RNA of human terminal ileum and the oligonucleotides

The obtained cDNA and DNA of plasmid pcdNAneo were digested using the two restriction enzymes mentioned and resulting fragments were combined by means of ligase to give the expression plasmid pHBAT8.

A commercially available cDNA gene bank prepared as starting material for the plasmid¹⁰ for the preparation of the HLBAT-producing cell line (pHLBAT5). From this by means of a PCR procedure (polymerase chain reaction) with the aid of the oligonucleotides

5'-cagatgacggccgaactctttagagggtgcctgagcagc-3', a cDNA was synthesized which contained the total protein-coding region of the HLEAT, and also 7 base pairs on the 5' adjacent and 8 base pairs on the 3' adjacent untranslated region. This region was flanked by cleavage sites for the restriction enzymes BamHI (at the 5' end) and XbaI (at the 3' end). The obtained cDNA and DNA of plasmid pCDNA3neo were digested using the two restriction enzymes mentioned, resulting fragments were combined by means of ligase to give the expression plasmid pHLEAT5.

For the preparation of the genetically modified cell lines, CHO cells were transfected with DNA from PIRABT-pH-RAT5 and cells which developed resistance against the selection substance G418 were selectively cultured by addition of the substance to the cell medium. The cells CHO-PIRABT5, CHO-PH-RAT5 and additionally cultured by addition of the substance to the cell medium. The cells CHO-PIRABT5 were cultured therefrom. The tool used for following the isolation process was in this case a fluorescent bile acid derivative (9 α -NBD-NCT). With intact bile acid transporters rapidly absorb the substance from the cell medium and as a result become fluorescent. In contrast, bile acid transporters quickly absorb the substance from the cell medium and as a result become fluorescent. Cells could thereby be easily differentiated from cells without intact bile acid transporters with the aid of a fluorescence microscope.

All three lines transported radiolabeled taurocholic acid efficiently from the extracellular medium into the cell interior. This process was sodium-dependent. In contrast to this, CHO cells without intact bile acid transporters only absorbed very small amounts of taurocholic acid. Building on this knowledge, a characterization of test substances according to the inversion was carried out as follows: cells of the type CHO/pH18A9, CHO/pH18A78 or CHO/pH18A75 were simultaneously exposed in culture dishes to radiolabeled taurocholic acid and a test substance and the absorption of radioactive material by the cells was measured. The test substance concentrations here were varied systematically from dish to dish and all other parameters were kept constant. To prepare them for experiment, the cells were routinely cultured in medium (minimum essential medium (MEM), 1% MEM non-essential amino acid solution, 10% fetal calf serum, 400 g/l of CO₂ (8) in culture flasks, 100 µl removed from their environment by means of a pipette, inoculated in defined form into culture dishes (diameter: 3.5 cm) and additionally cultured in medium. Shortly before reaching confluence, the medium was removed from the cells and the contents of each dish were washed with 2 times 1.5 l of PBS. (Dulbecco's phosphate-buffered saline solution). After removing the wash solution, 1 ml of a defined concentration of test substance in PBS was added to each dish and they were incubated at 21°C for 30 minutes. This preincubation solution was then replaced by a test solution which contained 12 µl of taurocholic acid in a concentration of 3.3 µM and also of a specific radioactivity of 7400 Bq/ml. But otherwise had the same volume and the same composition as the pre-incubation solution. The cells were exposed to the test solution at 21°C for 30 minutes and then washed with 5 times 1.5 ml of PBS per dish. To lyse the cells, 1 ml of an aqueous solution containing 0.1 mol/l of NaOH and 0.1 % (w/v)(10 µl) of SDS was added to each dish, which was incubated for 30 minutes at 21°C and triturated. Finally, the contents of each dish were mixed with 10 ml of a commercially available scintillation solution and the radioactivity taken up by the cells was determined with the aid of a scintillation-measuring apparatus.

To assess the transport results, the radioactivity values were not plotted directly, but their % relationship to a control value in the case of which measurement had been carried out without inhibiting test substance. Half-maximal inhibition values (IC_{50}) resulted from this graphically or arithmetically:

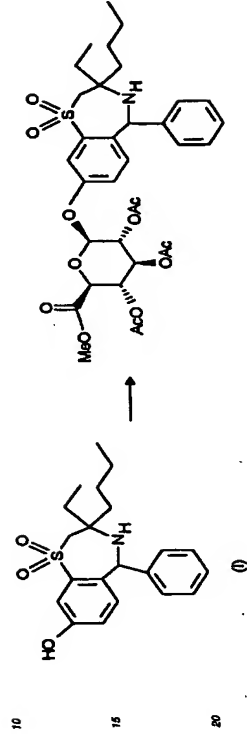
Example 3	IC ₅₀ (R1B1AT)	70 nM = 0.07 μM
Example 11 of WO 96/05188	IC ₅₀ (R1B1AT)	4 μM

An analogous investigation of the effect of the same substances on the transport of the cell line CHO/pH2BTA showed that here the corresponding IC₅₀ value varied approximately within the same order of magnitude. In contrast to

this, the IC_{50} value determined with the cell line CHO β -HLBATS was several powers of ten higher. This shows that compounds according to the invention can exert a comparable effect on orthologous sodium-dependent bile acid transporters of various species and, in contrast to this, the effect on paralogous transporters of other organs can be very much smaller.

For a better understanding of the invention, the following Example is given by way of illustration and is (e.g. with N,N-carbonyl-dlimidazole) not to be construed in any way as limiting the scope of the invention.

Example 1

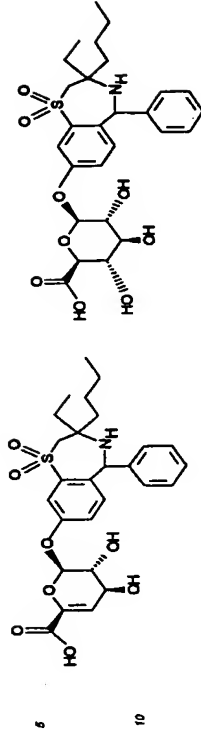


To a solution of 2.9 g methyl-2,3,4-tri-O-acetyl- α -glucuronate in 100 ml dry dichloromethane at room temperature under Argon is added 4.6 ml trichloroacetonitrile and the solution is stirred for 10 min. Then 780 mg potassium carbonate is added. After 30 min of stirring at room temperature the mixture is filtered through a short pat of silica, eluting with ether. The filtrate is concentrated in vacuo to yield the crude product as a pale yellow solid (3.7 g). 1.0 g of this product were dissolved in 15 ml dry dichloromethane and added to a solution of Phenol 1 (trans racemate) in 30 ml dry dichloromethane. After cooling to -10°C 0.32 ml $\text{BF}_3 \cdot \text{OEt}_2$ were added and after 30 min at -10°C the mixture was stirred for 20 h at room temperature. Then the reaction was diluted with dichloromethane and washed with aqueous sodium bicarbonate and brine. The combined organic phases were dried over Na_2SO_4 and evaporated in vacuo. The crude product was purified by silica gel chromatography (n-heptane/ethyl acetate, 2:1) to obtain 625 mg of Example 1.

$R_f=0.17$ (n-heptane/ethyl acetate 1:1).

$\text{C}_{27}\text{H}_{33}\text{NO}_{12}\text{S}$ (689); MS (FAB, 3-NBA): 680 (M+H+)

Example 2



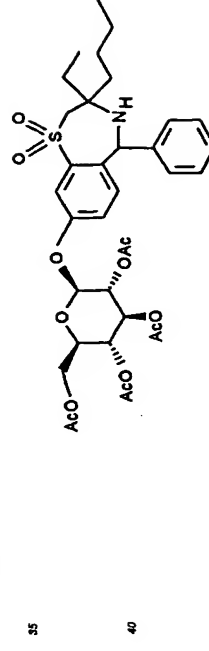
Example 3

To a solution of 900 mg Example 1 in 45 ml methanol were added 15 ml of 1N NaOH. After 4h at room temperature 150 ml H_2O were added and the organic solvent evaporated in vacuo. The aqueous solution was adjusted to pH 3 with 2N HCl and evaporated to dryness. Chromatography over silica gel ($\text{CH}_2\text{Cl}_2/\text{MeOH}$ 3:3 % aq. NH_3 , 30:10:3) yielded two fractions.

1. Fraction: Example 2, $R_f=0.85$ ($\text{CH}_2\text{Cl}_2/\text{MeOH}$ 3:3 % aq. NH_3 , 30:10:3) ($\text{C}_{27}\text{H}_{33}\text{NO}_{12}\text{S}$ (531); MS (ESI): 532 (M+H+)

2. Fraction: Example 3, $R_f=0.52$ ($\text{CH}_2\text{Cl}_2/\text{MeOH}$ 3:3 % aq. NH_3 , 30:10:3) ($\text{C}_{27}\text{H}_{33}\text{NO}_{12}\text{S}$ (549); MS (FAB, 3-NBA): 550 (M+H+)

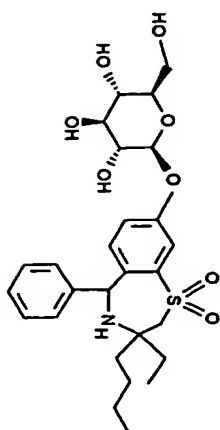
Example 4



Example 4 was obtained in analogy to example 1

$R_f=0.20$ (n-heptane/ethyl acetate 1:1)
 $\text{C}_{35}\text{H}_{43}\text{NO}_{12}\text{S}$ (703); MS (ESI): 704 (M+H+)

Example 5



Example 5 was obtained in analogy to example 2

$R^4 = 0.20$ ($\text{CH}_2\text{CH}_2\text{MeOH}$ 33 % eq. NH_3 , 60:10:3)
 $\text{C}_{27}\text{H}_{37}\text{NO}_5$ (335); MS (FAB, 3-NEBA): 336 (M⁺H⁺)

NMR-data of Example 3

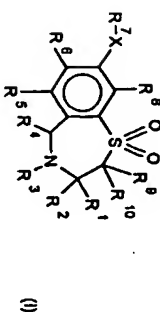
Chemical Shifts in $\text{MeOD}-d_4$ at 300 K				
Position	Isomer A ^1H	Isomer B ^1H	Isomer A ^{13}C	Isomer B ^{13}C
1	-	-	58.51	58.51
2	3.50/3.14	3.50/3.16	64.63	64.63
3	-	-	142.36	142.36
4	-	-	140.61	140.61
5	6.00	6.01	55.74	55.74
6	1.57/1.44	1.57/1.44	34.38	34.38
7	0.88	0.88	7.94	7.94
8	2.22/1.79	2.22/1.79	31.85	31.85
9	1.17	1.17	26.22	26.22
10	1.26	1.26	24.06	24.06
11	0.81	0.81	14.31	14.31
12	-	-	143.98	143.98
13	7.39	7.39	129.05	129.05
14	7.38	7.38	129.36	129.36
15	7.29	7.29	128.09	128.09
16	6.61	6.61	131.10	131.10
17	7.17	7.17	121.72	121.72
18	-	-	157.69	157.69
19	7.72	7.73	117.81	117.81

(continued)

Chemical Shifts in $\text{MeOD}-d_4$ at 300 K				
Position	Isomer A ^1H	Isomer B ^1H	Isomer A ^{13}C	Isomer B ^{13}C
20	4.91	4.91	102.46	102.46
21	3.48	3.48	74.62	74.62
22	3.48	3.48	77.71	77.71
23	3.50	3.50	73.53	73.53
24	3.70	3.70	76.45	76.45
25	-	-	176.21	176.21

1. Claims

1. A compound of the formula (I)



wherein

R^1

R^2

R^3

R^4

R^5 , R^6 and R^8

R^7

R^9

R^{10}

R^{11}

R^{12}

R^{13}

R^{14}

R^{15}

R^{16}

R^{17}

R^{18}

R^{19}

R^{20}

R^{21}

R^{22}

R^{23}

R^{24}

R^{25}

R^{26}

R^{27}

R^{28}

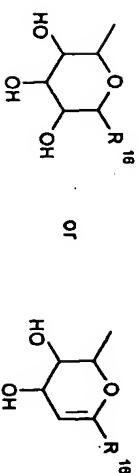
R^{29}

R^{30}

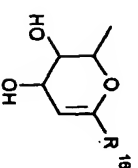
R^{31}

R^{32}

R^{33}



OR



wherein the hydroxyl groups may be substituted by acetyl oder benzyl, or $-(C_1-C_6)\text{-alkyl-R}^{17}$

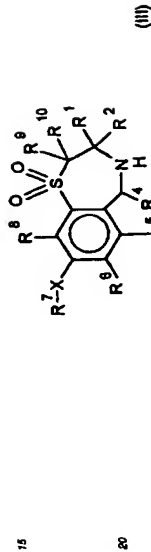
6
 R^{16}
 R^{17}
 R^{18}
 X

wherein the alkyl group may be substituted with one or more hydroxyl groups;
 is $-COOH$, $-CH_2OH$, $-CH_2O\text{-Acetyl}$, $-COOMe$ or $-COOEt$

is H , $-OH$, $-NH_2$, $-COOH$ or $COOR^{18}$,
 is $(C_1-C_6)\text{-alkyl}$ or $-NH(C_1-C_6)\text{-alkyl}$;
 is $-NH$ - or $-O$ -; and

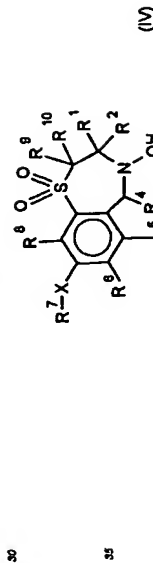
10
 R^9 and R^{10} are the same or different and each is hydrogen or C_{1-8} alkyl;
 and salts, solvates, and physiologically functional derivatives thereof.

2. The compounds as claimed in claim 1 which are of the formula (III)



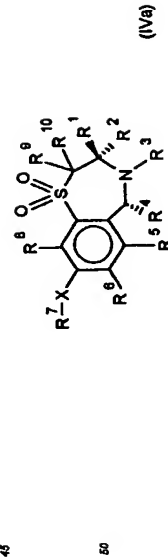
wherein R^1 to R^{10} and X are as defined in claim 1.

3. The compounds as claimed in claim 1 which are of the formula (IV);



wherein R^1 to R^{10} and X are as defined in claim 1.

4. The compounds as claimed in claim 1 which are of the formula (IVa)



wherein R^1 to R^{10} and X are as defined in claim 1.

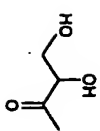
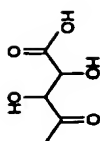
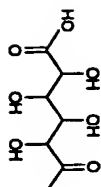
5. A compound according to any of the claims 1 to 4 wherein R^7 is selected from



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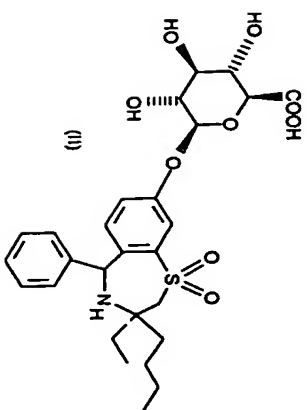
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and X is -O-.

6. A compound of the formula



prises, administering to a mammal an effective bile acid uptake inhibition amount of a compound according to any of the claims 1 to 6.

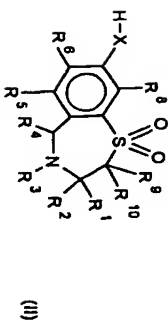
10. A method of treating a hyperlipidemic condition in a mammal which comprises, administering to the mammal an effective hyperlipidemic treatment amount of a compound according to any of the claims 1 to 6.

11. The method of claim 10 wherein the hyperlipidemic condition is atherosclerosis.

12. Use of a compound according to any one of claims 1 to 6 or a pharmaceutically acceptable salt, solvate, or physiologically functional derivative thereof in the manufacture of a medicament for the prophylaxis or treatment of a clinical condition for which a bile uptake inhibitor is indicated.

13. A method for the preparation of a compound according to any one of the claims 1 to 6 and salts, solvates, and physiologically functional derivatives thereof, which comprises

a) cyclization of a compound of formula II



by standard procedures at the -X-H group
or

a) silylation a compound of formula II by standard procedures at the -X-H group

a) glycosylation or glucuronidation a compound of formula II at the -X-H group, and
b) cleavage of protecting groups, especially of hydroxy and amino functional groups.

7. A pharmaceutical composition comprising one or more compounds according to any of the claims 1 to 6.

8. A acid and gastric juice resistant pharmaceutical composition comprising one or more compounds according to any of the claims 1 to 6.

9. A method of treating a clinical condition in a mammal for which a bile acid uptake inhibitor is indicated which com-

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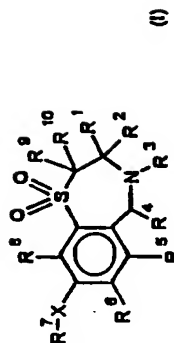
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(71) Applicant:
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(54) Hypolipidemic 1,4-benzothiazepine-1'-dioxides

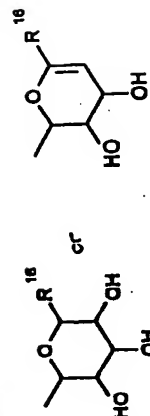
(57) The present invention is concerned with new hypolipidemic compounds (I) and with their use in medicine, particularly in the prophylaxis and treatment of hyperlipidemic conditions, such as atherosclerosis.

Compounds of the formula (I):



wherein X is -NH- or -O-; and

R¹ is a group of the formula



wherein the hydroxyl groups may be substituted by acetyl or benzyl, or

-(C₁-C₃)-alkyl-R¹⁷
wherein the alkyl group may be substituted with one or more hydroxyl groups;

R¹⁶ is -COOH or -CH₂-OH;

R¹⁷ is H, -OH, -NH₂, -COOH or COOR¹⁸;

R¹⁸ is (C₁-C₃)-alkyl or -NH-(C₁-C₃)-alkyl.

Category	Category of document with indication, where appropriate, of relevant passages	Referred to claim to define	CLASSIFICATION OF THE APPLICATION (IPC Class)
X	NO 93 16955 A (THE WELLCOME FOUNDATION LIMITED) 19 August 1993 * the whole document *	1-5, 7-13	C02H17/08 C02H28/08 C02H41/04 C07F9/5536 C07F9/5558 A61K31/78 A61K31/75 A61K31/075
X	NO 94 18183 A (THE WELLCOME FOUNDATION LIMITED) 18 August 1994 * the whole document *	1-5, 7-13	
X	NO 94 18184 A (THE WELLCOME FOUNDATION LIMITED) 18 August 1994 * the whole document *	1-5, 7-13	
D, X	NO 95 05188 A (THE WELLCOME FOUNDATION LIMITED) 22 February 1996 * the whole document *	1-5, 7-13	
<p>DOCUMENTS CONSIDERED TO BE RELEVANT</p>			
<p>INCOMPLETE SEARCH</p> <p>The Search Division considers that the printed specification, or one or more of the claims, cannot be searched with the EPO's search system and a non-specified search has been made of the art covered by the application. The search has been carried out on the basis of the art covered by the application and the results are given in the following table.</p> <p>Claims searched completely:</p> <p>Claims searched incompletely:</p> <p>Claims not searched:</p> <p>Reasons for the limitation of the search:</p> <p>Although claims 9-11 are directed to a method of treatment of the human/animal body (Article 52(a) EPC), the search has been carried out and based on the alleged effects of the compound/composition.</p>			
<p>Page of search</p> <p>THE HASBIE</p>		<p>Date of completion of the search</p> <p>9 June 1998</p>	<p>Examiner</p> <p>Alford, M</p>
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X: published under E: taken alone Y: published under E: taken in combination with other documents A: International Bibliography P: International Database 1: Theory or principle underlying the invention 2: Prior art known to the applicant 3: Document cited in the application 4: Document cited in the abstract 5: Document cited in the claims 6: Document cited in the description 7: Document cited in the summary of the invention 8: Document cited in the conclusions</p>			

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